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Serial/Patent No.: 09/914,928

Filing/Issue Date: 9/6/01

Applicant: Loick Verger et al.

Title: X-RADIATION IMAGERY DEVICE AND PROCESS FOR MAKING THIS DEVICE

TRP Docket No.: 034299-000346

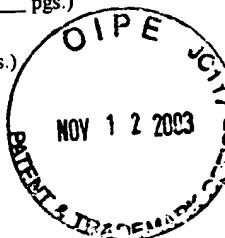
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Date Mailed: 11-7-03

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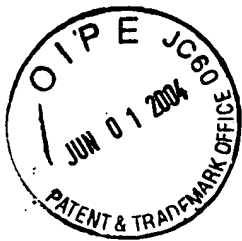
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| <input type="checkbox"/> Appeal Brief (____ pgs.) (in triplicate) | <input checked="" type="checkbox"/> 1 Pieces of Prior Art Enclosed |
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Deposit Acct. No. 50-1698 \$ ____

Patent Code: 1253/1806

Client/Matter # 34299 - 346



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: Loick Verger et al.
SERIAL NO.: 09/914,346
FILING DATE: September 6, 2001
TITLE: X-RADIATION IMAGERY DEVICE AND PROCESS FOR
MAKING THIS DEVICE
EXAMINER: Christine Sung (Tel. No.: (703) 305-0382)
(Fax No.: (703) 308,7722)
ART UNIT: 2878

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INFORMATION DISCLOSURE STATEMENT

Each item of information listed in the attached FORM PTO-1449, for which a copy of each is attached, may be material to the examination of the above-identified application and is, therefore, submitted in compliance with the duty of disclosure defined in 37 CFR §§ 1.56, 1.97 and 1.98. The Examiner is requested to make these items of official record in this application.

This Information Disclosure Statement under 37 CFR §§ 1.56, 1.97 and 1.98 is not to be construed as a representation that a search has been made, that additional information material to the examination of this application does not exist, or that any one or more of these items constitutes prior art.

I

This statement is filed pursuant to:

() 37 C.F.R. § 1.97(b).

This information disclosure statement is filed either (1) within three months of the filing date of a national application other than a continued prosecution application under §1.53(d); (2) within three months of the date of entry of the national stage as set forth in 37 C.F.R. § 1.491 in an international application; (3) before the mailing date of a first office action on the merits, or (4) before the mailing of a first office action after the filing of a Request for Continued Examination under 37 C.F.R. § 1.114, whichever event occurs last.

Accordingly, this information disclosure statement requires no fee and no certification.

(X) 37 C.F.R. § 1.97(c).

This information disclosure statement is filed after the period specified in 37 C.F.R. § 1.97 (b), but before the mailing date of either (1) a final action under 37 C.F.R. § 1.113; (2) a notice of allowance under 37 C.F.R. § 1.311; or (3) an action that otherwise closes prosecution in the application.

Accordingly, this information disclosure statement requires either the fee specified in 37 C.F.R. § 1.17 (p) for submission of an information disclosure statement under 37 C.F.R. § 1.97 (c) (\$180); or a certification according to 37 C.F.R. § 1.97 (e).

() 37 C.F.R. § 1.97(d).

This information disclosure statement is filed after the period specified in 37 C.F.R. § 1.97 (c).

Accordingly, this information disclosure statement requires the fee specified in 37 C.F.R. § 1.17 (p) to consider an information disclosure statement under 37 C.F.R. § 1.97(d) (\$180), and a certification according to 37 C.F.R. § 1.97(e).

If this statement crosses in the mail with an office action, or is otherwise not in the indicated category of 37 C.F.R. § 1.97, it is respectfully requested that this statement be treated in the next appropriate category and made of record. To the extent required, please treat this paper as a conditional petition for acceptance of the information disclosure statement.

II

- () No fee is due.
- (x) The fee specified in 37 C.F.R. § 1.17(p) for submission of an information disclosure statement under 37 C.F.R. § 1.97(c) is enclosed (\$180).

Please charge any additional required fee or credit any overpayment to our deposit account number 50-1698. An additional copy of this page is enclosed.

III

Pursuant to 37 C.F.R. § 1.97(e), I certify:

- (X) No certification is necessary.
- () (1) Each item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the statement.
- () (2) No item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, or, to my knowledge after making reasonable inquiry, was known to any individual designated in 37 C.F.R. § 1.56(c), more than three months prior to the filing of the statement.

Respectfully submitted,
THELEN REID & PRIEST LLP

Dated: November 7, 2003



Masako Ando

Limited Recognition Under 37 CFR §10.9(b)

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CERN 1211 Geneva 23, Switzerland,

I. INTRODUCTION

Hybrid pixel detectors have evolved rapidly in the field of high energy physics. In particular the RD19 collaboration at CERN has developed 3 generations of pixel readout chips [1][2][3][4] starting with the 'LAA' prototype chip [1] with 9×12 pixels and culminating in the recent LHC1/Omega3 chip which contains 2 032 pixels in an array of 16×127 [4]. In the last two generations large multi-chip systems have been deployed successfully in high energy physics experiments. All throughout these developments γ -ray sources have been used as a means of calibrating the input charge and hence the threshold of the individual pixels. Clearly such devices could be used for γ -ray imaging and in several studies the potential for single particle counting pixel detectors with Si or GaAs has been put in evidence [5][6][7]. There were a number of limitations to the use of these devices for imaging. The readout architecture implemented in the pixel cells is tuned to the high energy physics environment, delaying the detected signals and requiring an

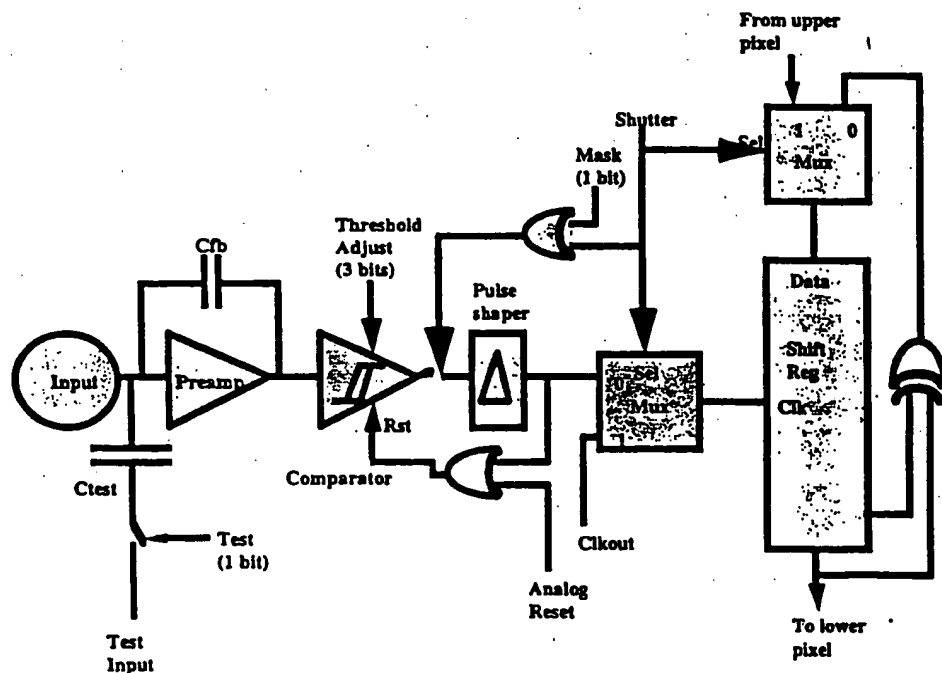


Figure 1: A block diagram of the pixel cell.

* This chip was developed as part of the Medipix project, a common development between CERN, University of Freiburg, University of Glasgow and INFN, Pisa (see Acknowledgements)

¹ Now with Nikhef, Amsterdam, The Netherlands and UC Santa Cruz. ² Now with INFN, Pisa, Italy.

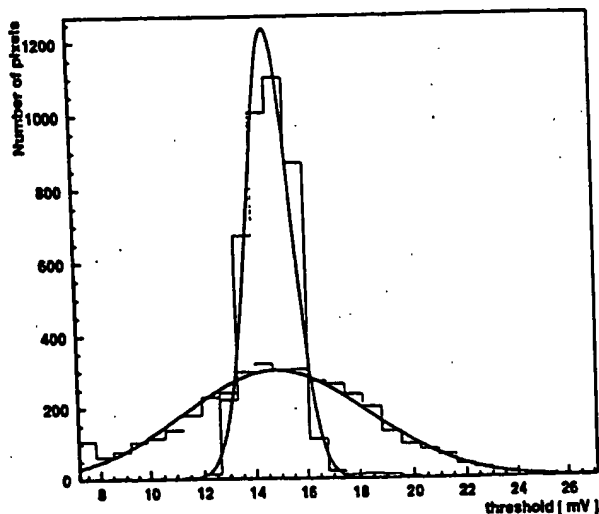


Figure 3: The distribution of thresholds on the chip. The mean threshold is around 15 mV corresponding to 1 400 e⁻. The variation is 350 e⁻ rms prior to adjustment and 80 e⁻ rms after adjustment.

counting rate per pixel. Pixels could be pulsed at a rate of up to 2 MHz without loss of counts. A further test was carried out on the imaging capabilities of one chip. The average threshold was fixed at 2 250 e⁻ without any local threshold adjustment. All of the pixels were unmasked and a test pattern of the CERN logo was introduced. With an open shutter time of 500 ms the chip was pulsed 1 000 times with an input signal of 3 300 e⁻. The result is shown in Figure 4. Noise in the pixels was negligible.

V. CONCLUSIONS AND FURTHER WORK

A 4 096 cell pixel readout chip has been presented which when bump-bonded to a detector can be used for imaging γ -ray photons and other particles. The threshold of each pixel can be adjusted individually. Wafer probing is being performed at present for selection of Known Good Die prior to bump-bonding. The chip will be bump-bonded to both Si and GaAs detectors. Adoption of sub-micron CMOS technologies will allow to obtain similar or better performance within a smaller pixel size as well as a variety of additional features depending on the specific application.

VI. ACKNOWLEDGMENTS

We gratefully acknowledge the collaboration and financial support of our partners in the Medipix project. In particular K. Smith and collaborators of the University of Glasgow, J. Ludwig and collaborators of the University of Freiburg and A. Stefanini and collaborators of the INFN, Pisa. G. Magistrati of Laben S.p.A., Milano provided the VME-based readout system and M. Conti and collaborators of the INFN, Napoli provided software for the readout system. Several people contributed to the testing of the chip. In particular P. Delogu, P. Maestro and S. Stumbo of INFN,

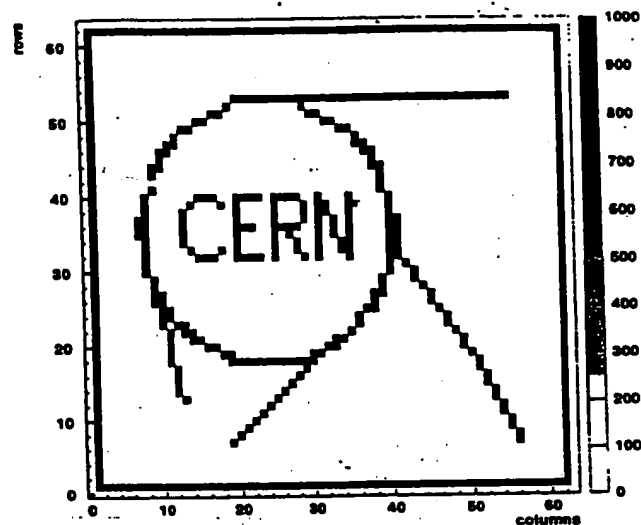


Figure 4: Results of a data acquisition using a test pattern corresponding to the CERN logo. This chip was pulsed 1 000 times. Only one noisy pixel is perceptible.

Pisa, J. Watt of the University of Glasgow and B. Mikulec participating in the Austrian fellowship program at CERN.

VII. REFERENCES

- [1] M. Campbell et al., "A 10 MHz CMOS front-end for direct readout of pixel detectors," *Nucl. Instr. and Meth. A* 290 (1990) 149.
- [2] F. Anghinolfi et al., "A 1006 element hybrid silicon pixel detector with strobed binary readout," *IEEE Trans Nucl. Sci.* NS-39 (1992) 654.
- [3] M. Campbell et al., "Development of a pixel readout chip compatible with large area coverage," *Nucl. Instr. and Meth. A* 342 (1994) 52.
- [4] E. H. M. Heijne et al., "LHC1: a semiconductor pixel detector readout chip with internal, tunable delay providing a binary pattern of selected events," *Nucl. Instr. and Meth. A* 383 (1996) 55.
- [5] C. Da Via', "Semiconductor pixel detectors for imaging applications," PhD Thesis University of Glasgow Scotland and CERN, Geneva, Switzerland (1997).
- [6] C. Da Via' et al., "Gallium arsenide pixel detectors for medical imaging," *Nucl. Instr. and Meth. A* 395 (1997) 148.
- [7] S. R. Amendolia et al., "Use of Silicon and GaAs Pixel Detectors for Digital Autoradiography," *IEEE Trans Nucl. Sci.* 44 (1997) 929.
- [8] P. Horowitz and W. Hill., "The Art of Electronics: Cambridge University Press (1980) 438.
- [9] P. Fischer et al., "A counting pixel readout chip for imaging applications," submitted to *Nucl. Instr. and Meth. A* (1997).

**READOUT for a
64 x 64 PIXEL MATRIX
with 15 - bit
SINGLE - PHOTON
COUNTING**

**Michael CAMPBELL,
Erik H.M. HEIJNE, Gerrit MEDDELER,
Elena PERNIGOTTI and Walter SNOEYS**

CERN ECP Division

**'Medipix' Collaboration
CERN, Freiburg, Glasgow, INFN Pisa**

**Nuclear Science Symposium
Albuquerque**

12 November 1997



PHOTON COUNTING CHIP

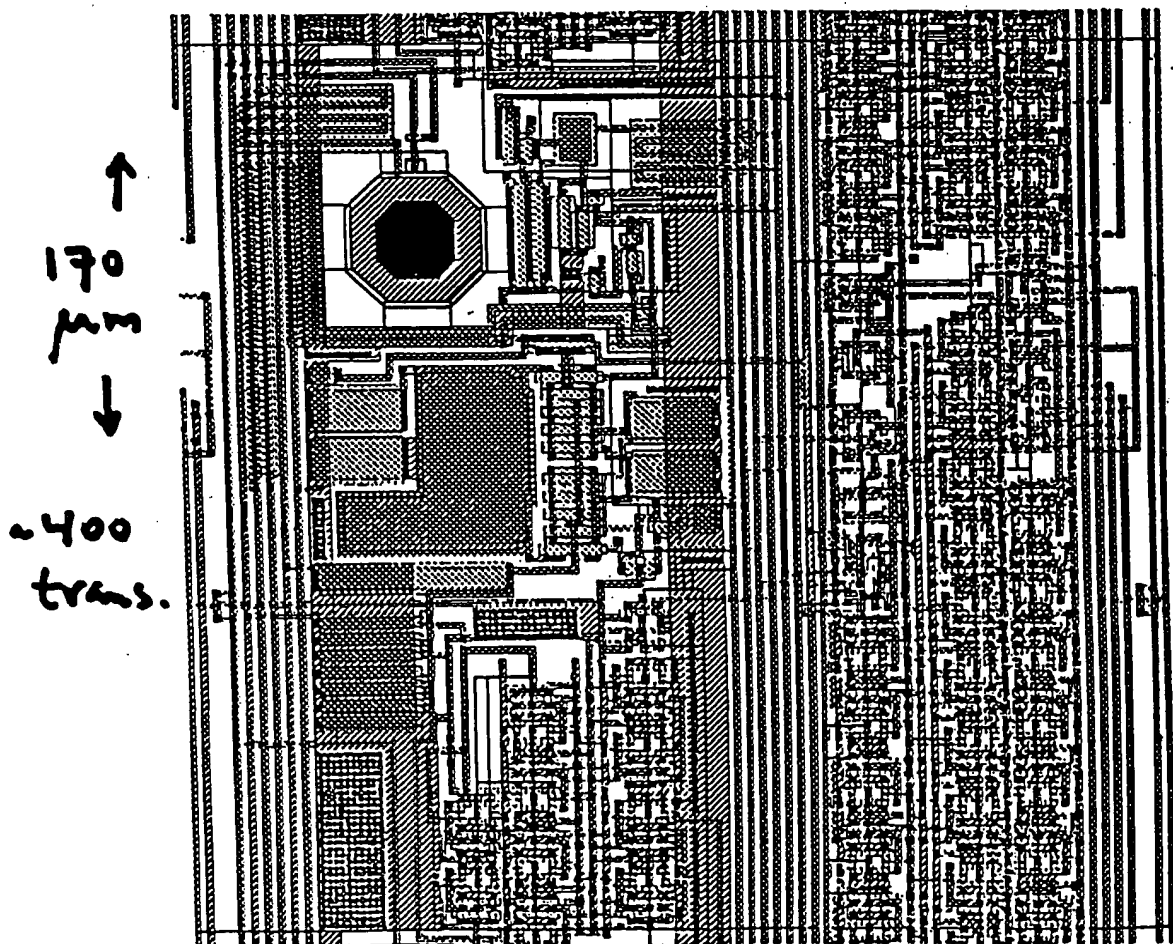
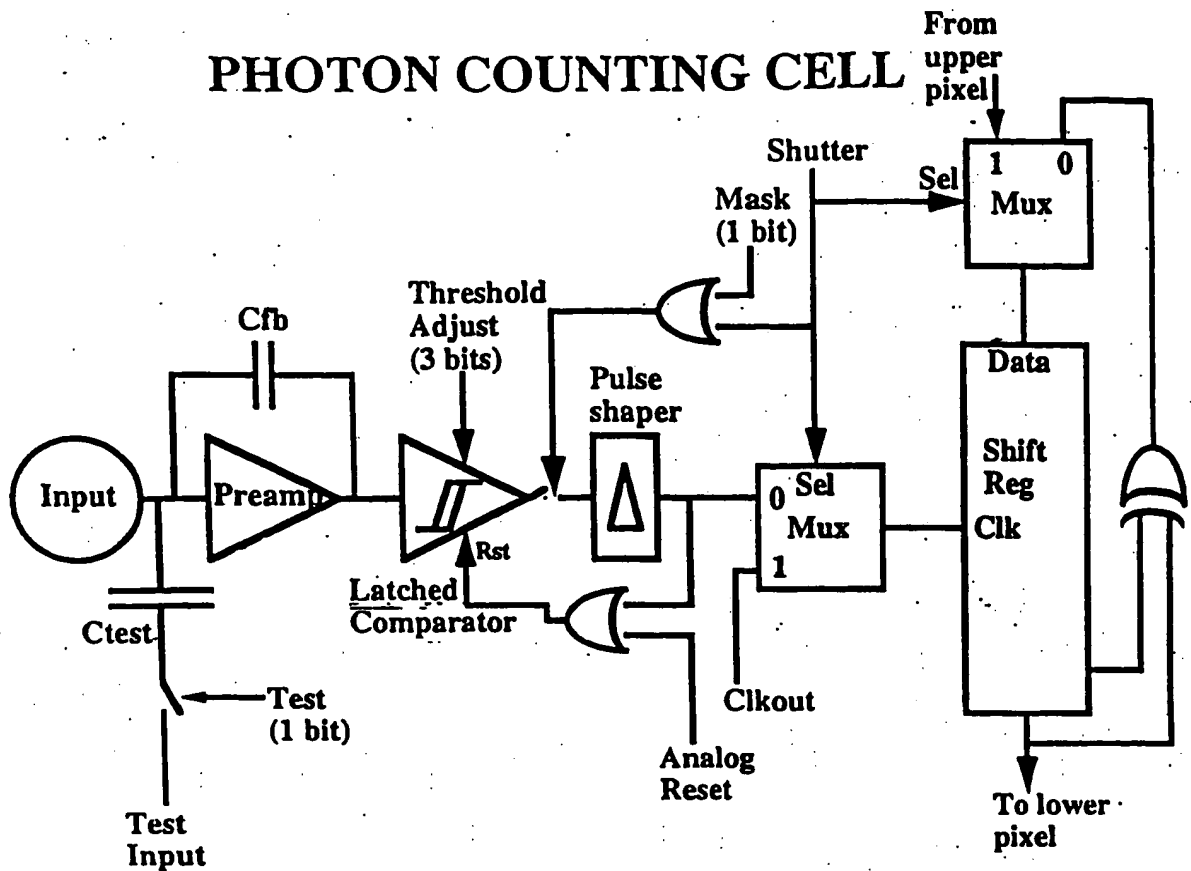
SUMMARY

**CELL 170 μm x 170 μm
400 transistors
MATRIX 64 x 64 CELLS
sensitive area 1 cm^2
CONTINUOUSLY SENSITIVE
FRONTEND
response time 150 ns
ADJUSTABLE THRESHOLD
spread 80 e- rms
SUMMING IN PIXEL
15 bit counter
EXTERNAL SHUTTER SIGNAL
static logic allows
long integration times
INDIVIDUAL CELL ADDRESSED
for TEST-SIGNAL
and MASKING**

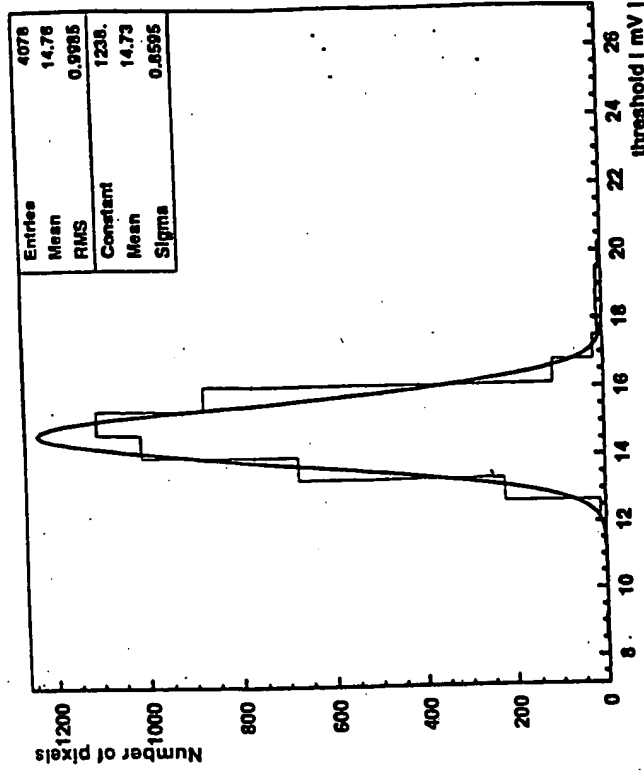
test patterns, no noise
CERN ECP Div. Silicon Detectors & Analog Microelectronics Erik HEIJNE
based on RD19 development



PHOTON COUNTING CELL



PCC 64x64 CELLS



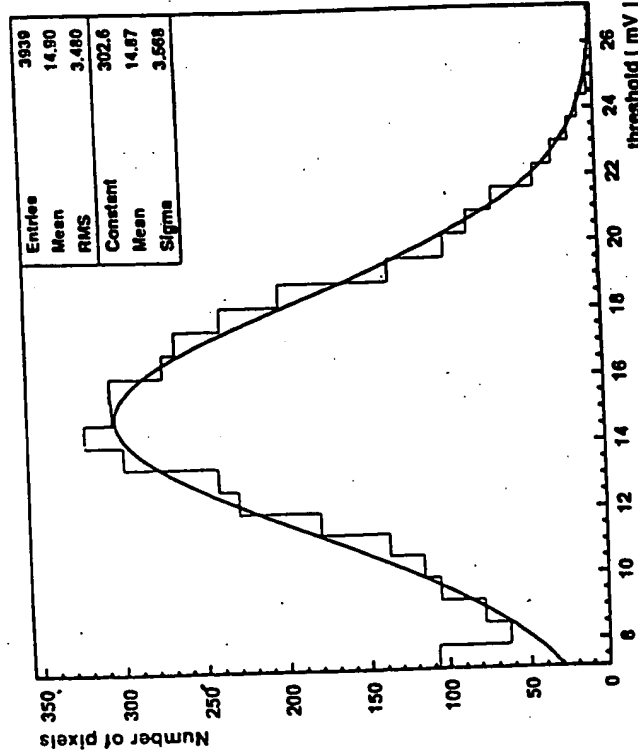
Threshold mean 1 400e-

Threshold variation 350e- unadjusted
80e- adjusted

3-BIT DIGITAL ADJUST IN EACH CELL

MICHAEL CAMPBELL
ELENA PERINQUOTTI et al.

PCC 64x64 CELLS



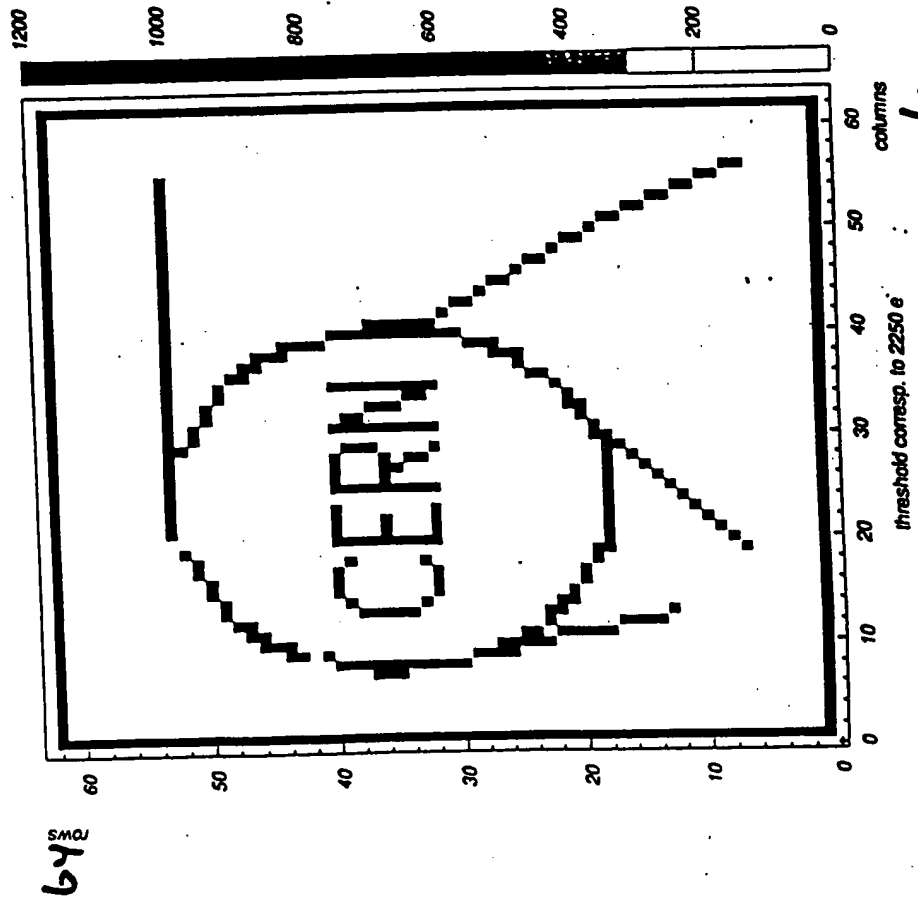
Threshold mean 1 400e-

Threshold variation 350e- unadjusted

→ INTERNAL ADJUSTMENT
USING 3-BIT REGISTER

PHOTON COUNTING CHIP

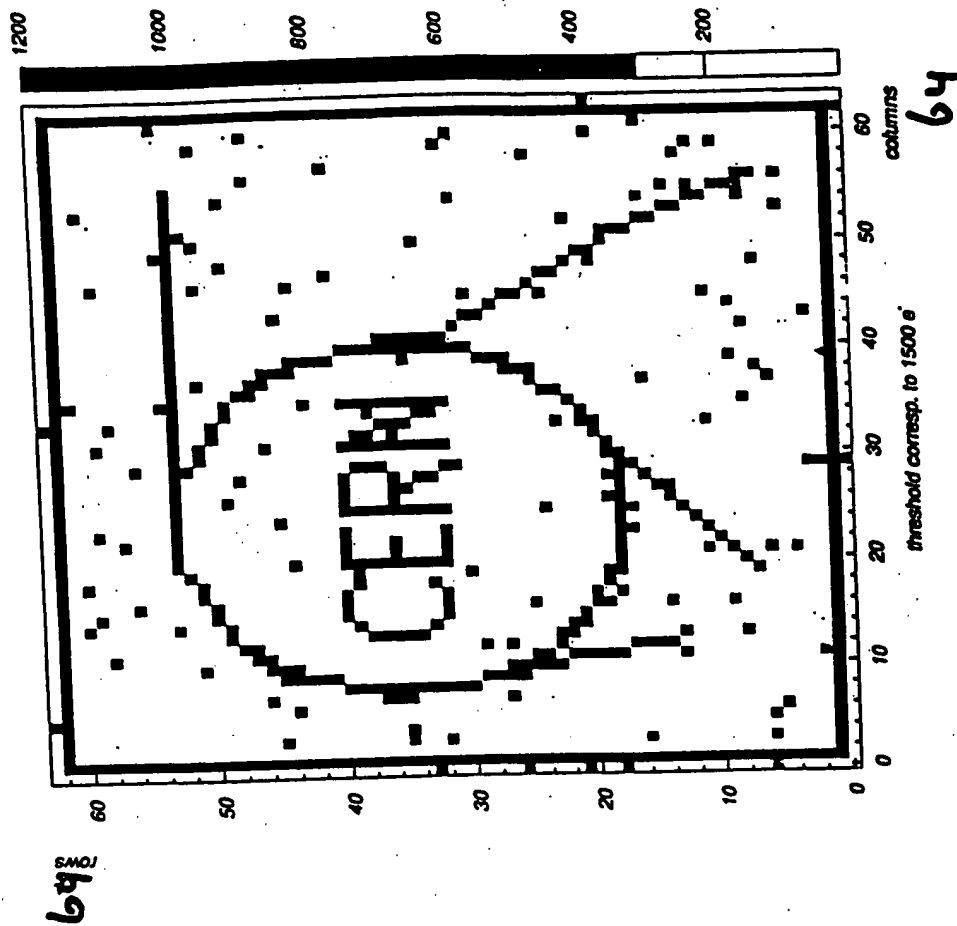
TEST PULSES 1000 X
NO MASKING APPLIED, ALL 4096 CELLS



THRESHOLD - 2250 e⁻ 8.2 keV

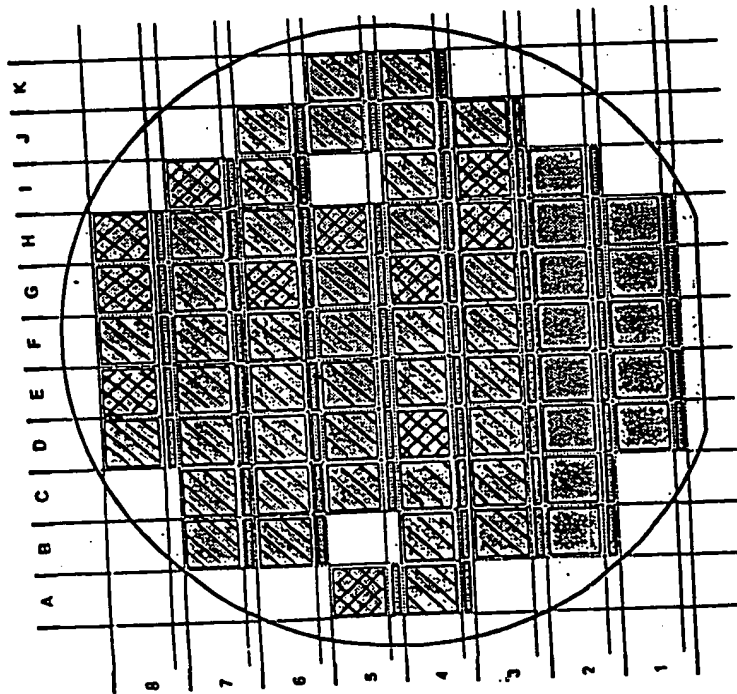
PHOTON COUNTING CHIP

TEST PULSES 1000 X



THRESHOLD - 1500 e⁻ 5.5 keV

WAFER PROBING

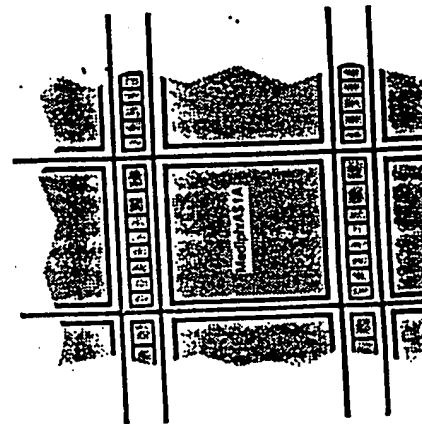


PHOTON COUNTING CHIP

FURTHER STEPS

PROBE TEST WAFER
Known Good Die
BUMPING & BONDING
GaAs & Si sensor chips
Multi Chip Array

SUBMICRON DESIGN
Smaller pixel cell
Multiple metal layers
----> BETTER DECOUPLING



Outre des découpages



CERN ECP Div. Silicon Detectors & Analog Microelectronics Erik HELNE

